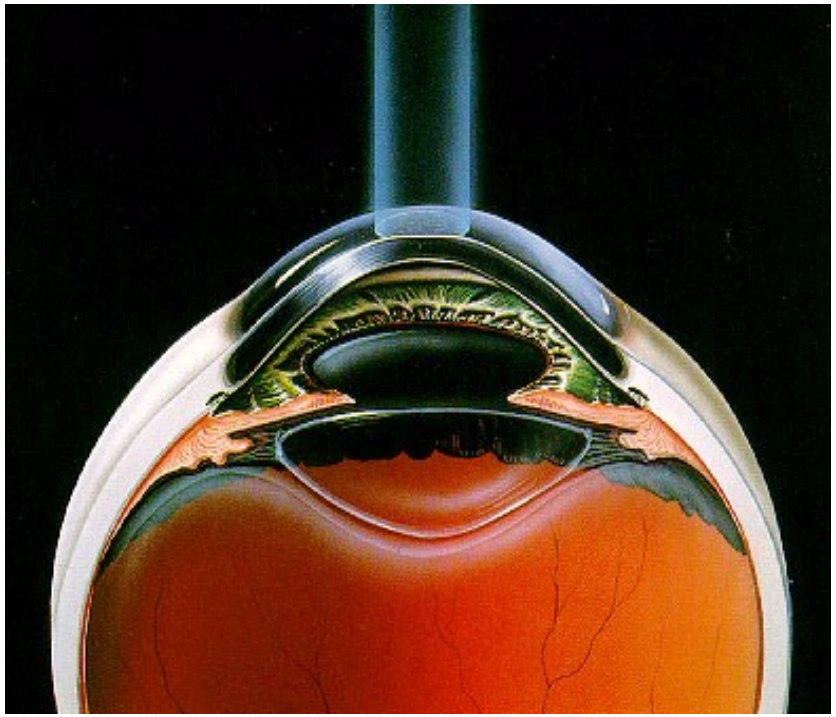
The Science of Corneal Refractive Surgery



Types

- Three main types of Corneal Refractive Surgery (CRS) discussed here
  - Radial Keratotomy (RK)
  - PhotoRefractive Keratectomy (PRK)
  - Laser In-Situ Keratomileusis (LASIK)

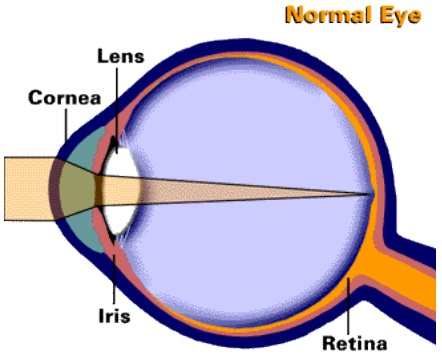
- Two other types mentioned here
  - Intrastromal Corneal Rings
  - Intraocular Contact Lens

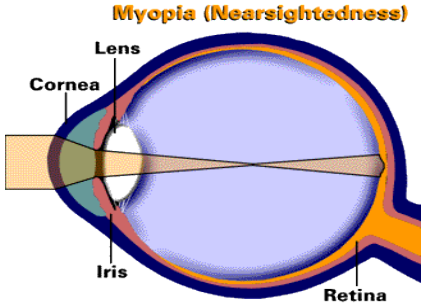
Definitions

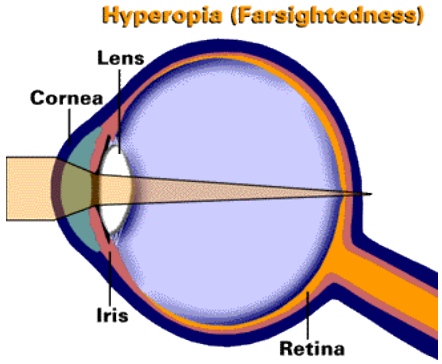
- Emmetrope = the naturally 20/20 eye; light rays focussed sharply on the retina
- Myopia (nearsighted) = difficulty with unaided distance vision; vast majority of CRS procedures are done for myopia; FDA approved PRK for correction in 1996
- Hyperopia (farsighted) = difficulty with unaided near vision; FDA approved PRK for correction very recently
- Astigmatism = uneven (non-spherical) curvature of cornea; FDA approved PRK for correction
- Presbyopia = stiffening of lens of eye which occurs with age and limits ability to adjust lens thickness (focus) for near vision; NOT FDA approved use of the excimer laser

Optics of the Eye

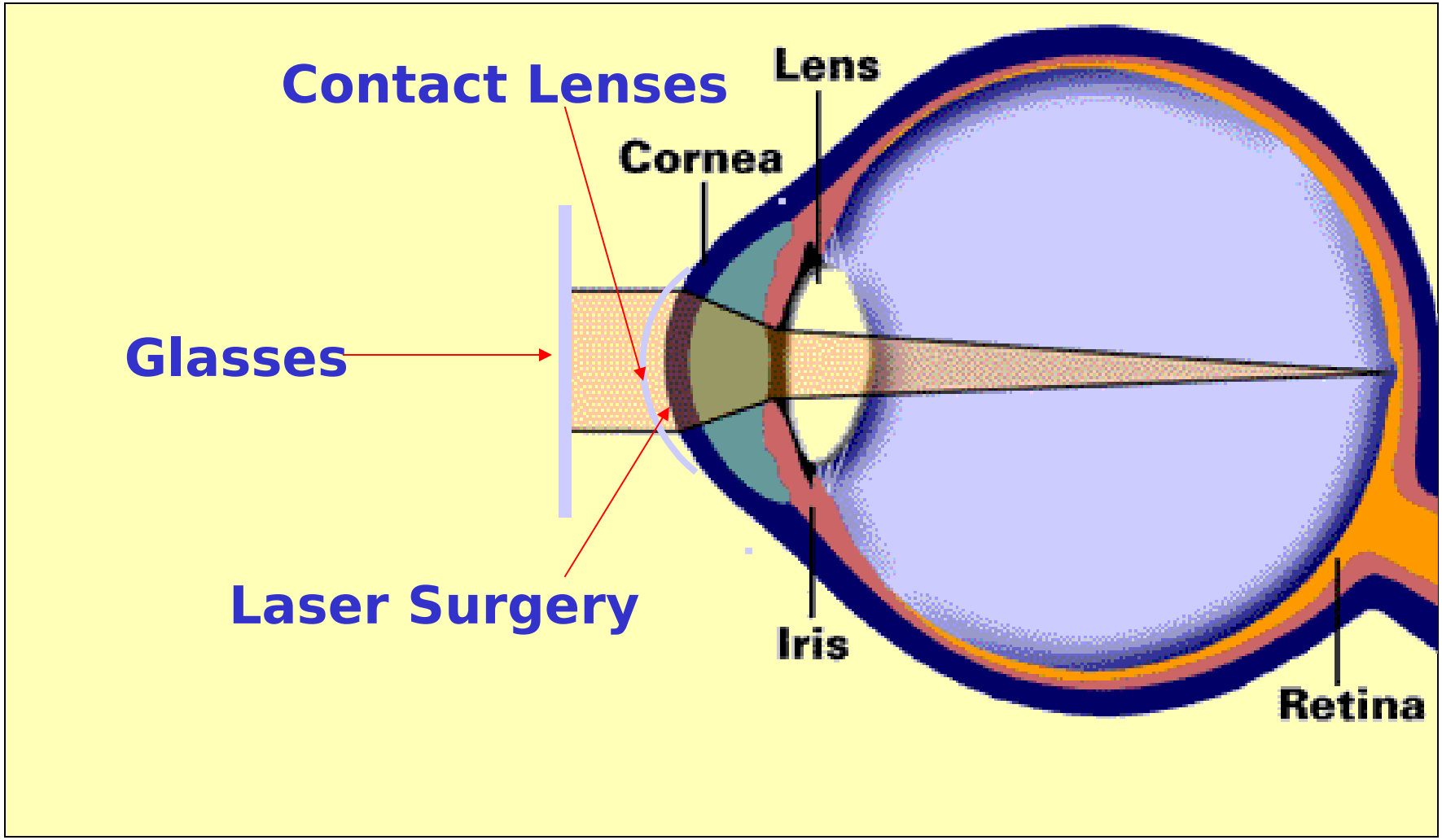
- Optically, the human eye is a “day VFR” system; vision is not as well-adapted to night as it is to day
- Focusing power of eye dependant upon the cornea, the lens and the effects of pupil size
- Near-sighted eye focuses in front of the retina (myopia)
- Farsighted eye focuses behind the retina (hyperopia)
- All CRS procedures act by altering the cornea’s curve, thus changing its focusing power



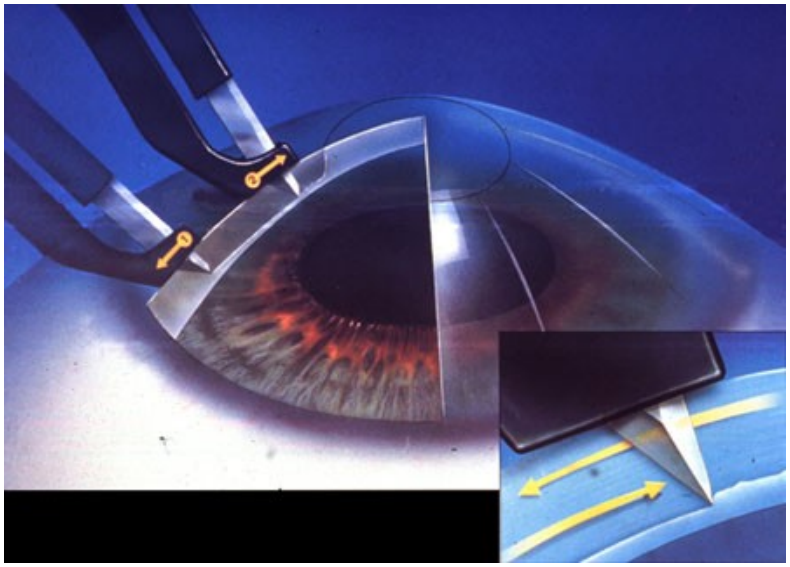


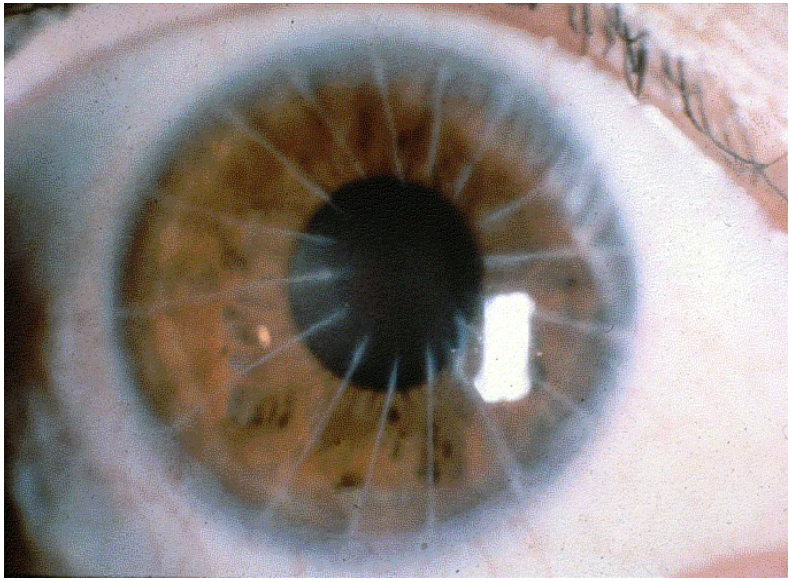


Changing the Focus Power



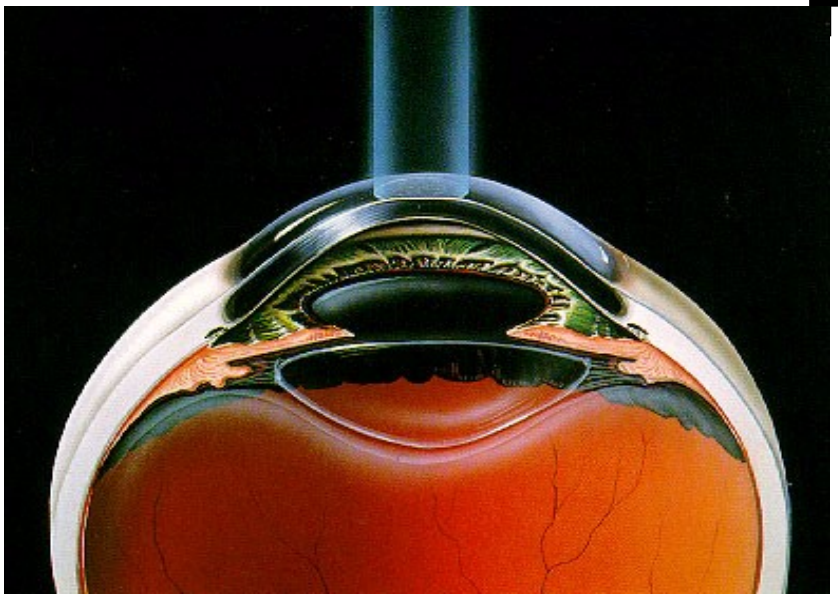
How to Alter Vision - RK

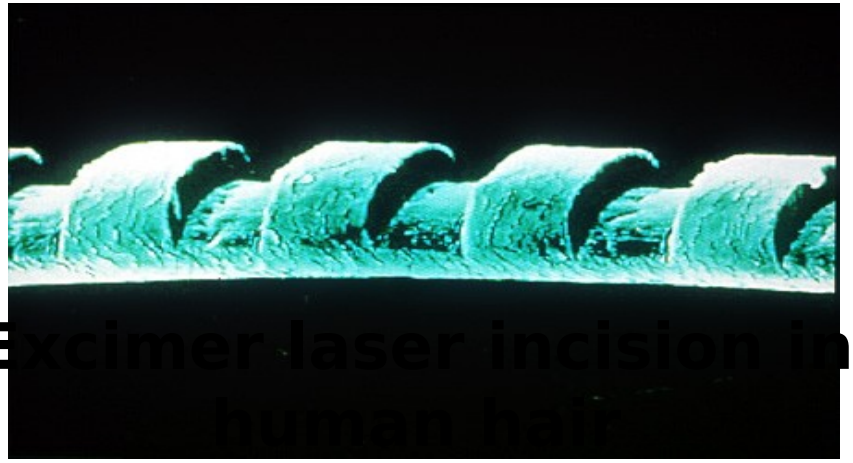




- Radial Keratotomy (RK) = series of deep radial cuts in the cornea
- Pros - may eliminate need for glasses
- Cons -
  - weakens eye
  - glare and halos from scars
  - vision deteriorates at altitude
  - vision progressively shifts over time

How to Alter Vision - PRK

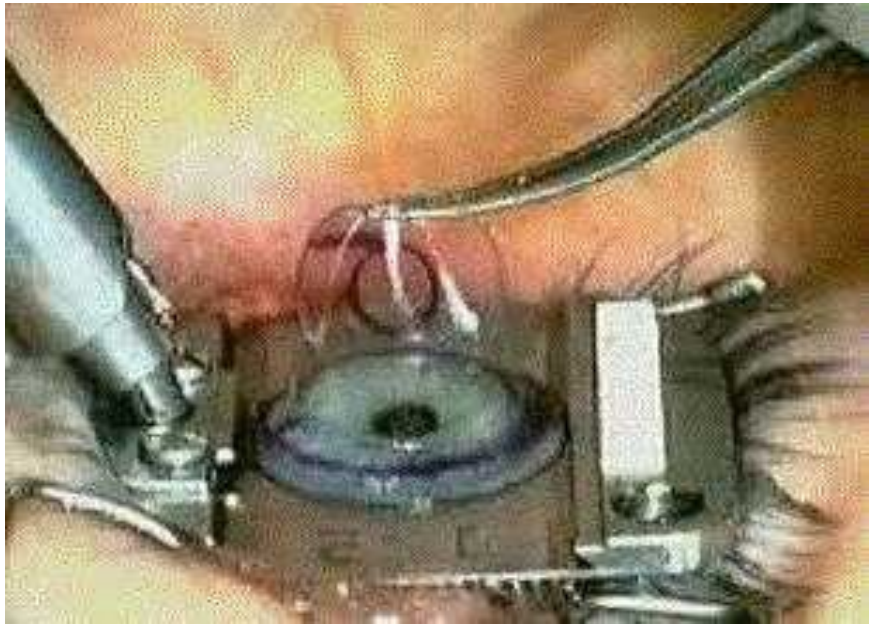




Excimer laser incision in human hair

- Photorefractive Keratectomy (PRK) = excimer laser sculpts front of cornea to change its lens power
- Pros - 75-80% no longer require glasses for 20/20 distance vision
- Cons -
  - 20-25% still require glasses for 20/20
  - ~1% risk of becoming disqualified for pilot duties
  - possible decrease in night vision and ability to detect camouflaged targets

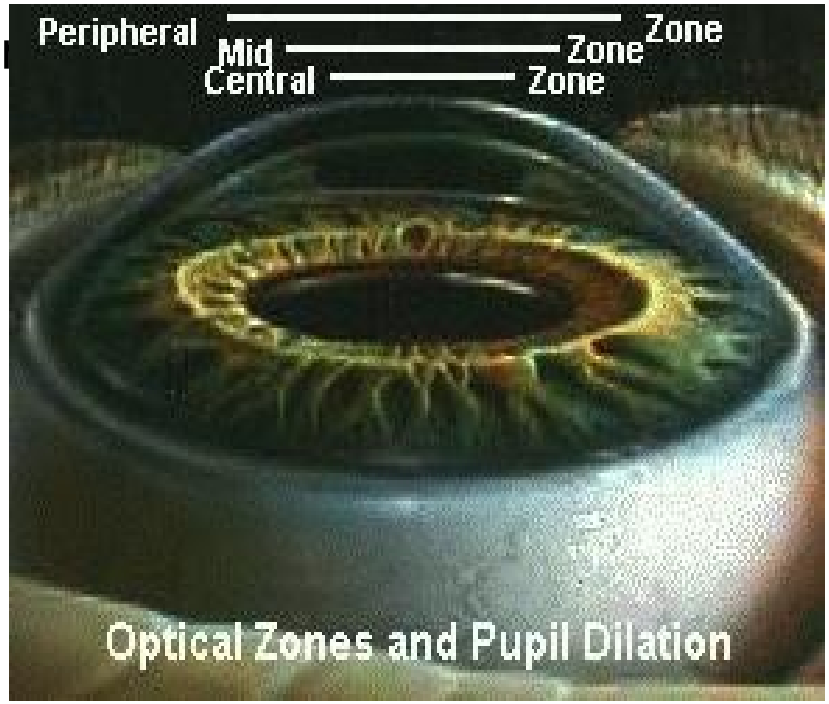
How to Alter Vision - LASIK



- Laser in-situ keratomileusis (LASIK) = slice a hinged flap then sculpt with excimer laser
- Pros - 75-80% no longer require glasses for 20/20
- Cons -
  - 20-25% still require glasses for 20/20
  - other cons as for PRK plus unknowns about late complications of cornea flap
  - flap can be lifted off during minor eye trauma

Optics of the Eye

- **Optical zones:** where > 90% of available light passes through the cornea. Cornea diameter is 11-13mm.
- **Central zone:** 3-4mm diameter; visio most effective; detail and color; daylight
- **Mid zone:** 5-7mm; moderate to moderately low light
- **Peripheral zone:** 7-10mm; low light/night conditions; dilated pupil
- **Laser ablation/transition zone sizes:** 6mm, 6.5mm and 7mm



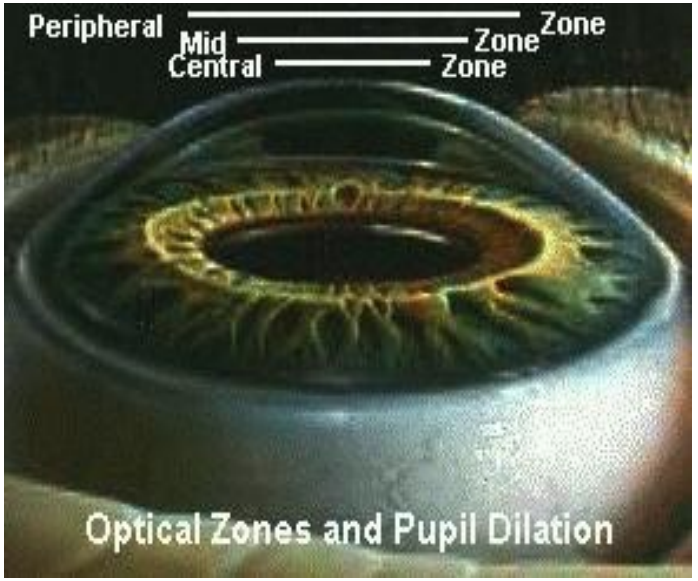
Optics After PRK and LASIK

- **Ablation zones:** after refractive surgery, three zones of <u>different</u> refractive power are present
- **Central ablation zone (3):** 4-6mm wide; full ablation; greatest change in power
- **Transition zone (2):** 1-2mm wide; circles central ablation zone; tapers the edge
- **Combined ablation zone** (central plus transition): 5-7mm
- **Untreated peripheral zone (1)**

Laser Surgery Ablation Zones: applies to both PRK and LASIK

Optics of PRK and LASIK Complications

- With CRS, scars may form in the ablation zone; the resultant haze within the optical zones accounts for glare, halos, and starburst effects

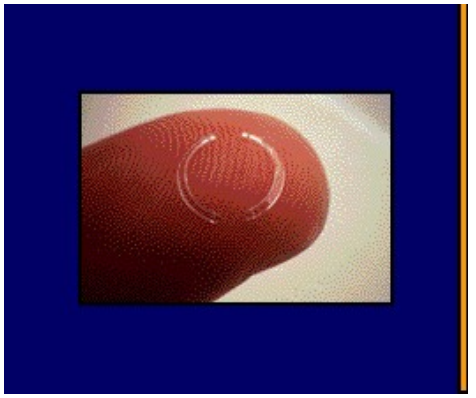


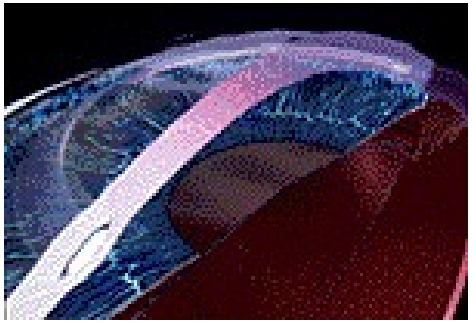
- Pupil dilation through the ablation zones changes optic performance and accounts for decreased contrast sensitivity (ability to see target against background), reduced night vision, glare, ghosts and double images

- The more nearsighted and the wider the pupils dilate the greater the risk of complications

Intrastromal Corneal Ring

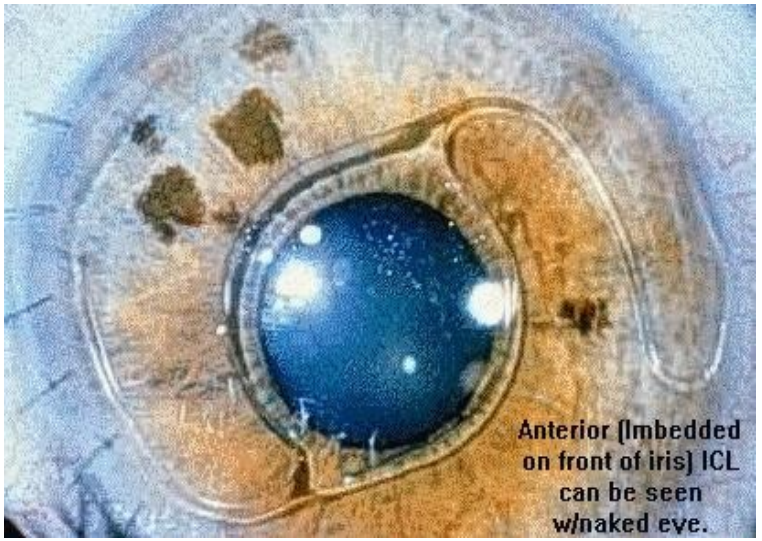
- FDA approved sale of the device 12 Apr 99
- Polymethylmethacrylate inlay inserted within the cornea tissue - added volume stretches and flattens the central cornea.
- Incision is 1/2-2/3 of cornea depth; insertion requires significant skill
- Company claims the procedure is reversible
- Currently approved for -1.0 to -3.5 diopters myopia; studies ongoing for -0.5 to -5.0 diopters myopia





Intraocular Contact Lens

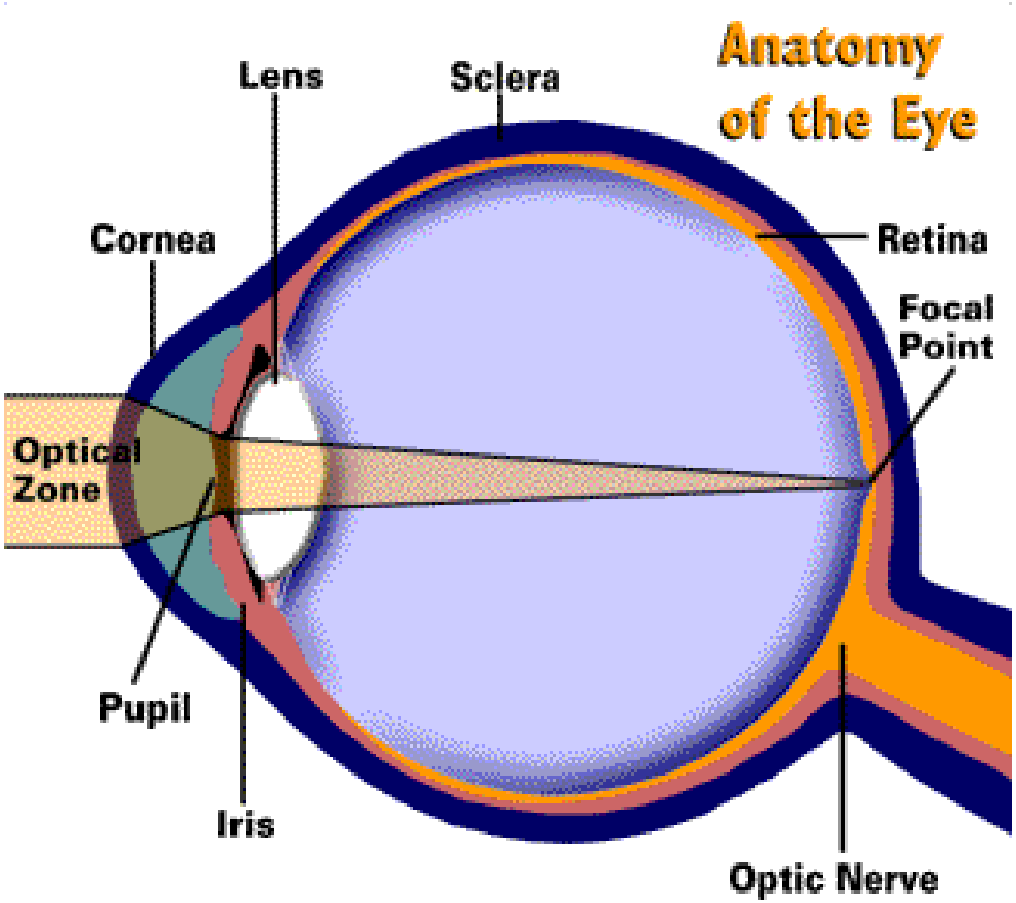
- Contact lens inserted directly into eye (either in front of or just behind iris)
- Highly invasive procedure
- Can induce cataracts in the natural lens within weeks
- Is related to intraocular lens implants used after the natural lens is removed for cataracts



References

- “Keratorefractive Surgery, Success, and the Public Health”, Editorial, by Dr. Leo J. Macguire, Mayo Clinic, printed in the American Journal of Ophthalmology (AJO), Vol. 117, No. 3, March 1994.
- American Institute of Biological Sciences Scientific Peer Advisory and Review Services “Report of the Peer Review Panel on Photorefractive Keratectomy (PRK) Research”
- Web site: “I Know Why Refractive Surgeons Wear Glasses” at http://members.aol.com/eyeknowwhy
  - A self-declared “negative” site which provides a much needed balance to the commercial marketing of these procedures
  - A “must-read”; contains multiple links
  - States military research in CRS is the most likely to be trusted
- Web site: surgicaleyes.com
  - Support group and reporting format for those with bad CRS outcomes
  - Recent testimony before FDA panel
  - Makes reasoned request for standardized pre-operative screening and standardized definition and reporting of complications

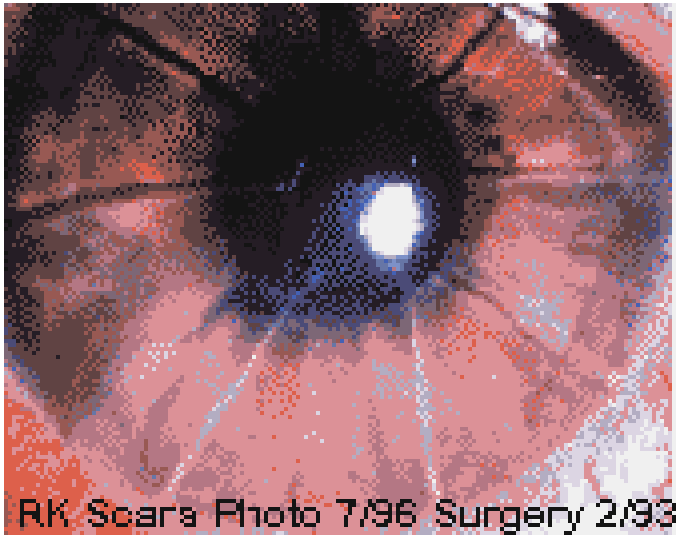
Eye Anatomy


Anatomy
of the Eye
Lens
Sclera
Cornea
Retina
Focal
Point
Optical
Zone
Pupil
Iris
Optic Nerve

Additional/Alternative PRK & LASIK Slides

Radial Keratotomy

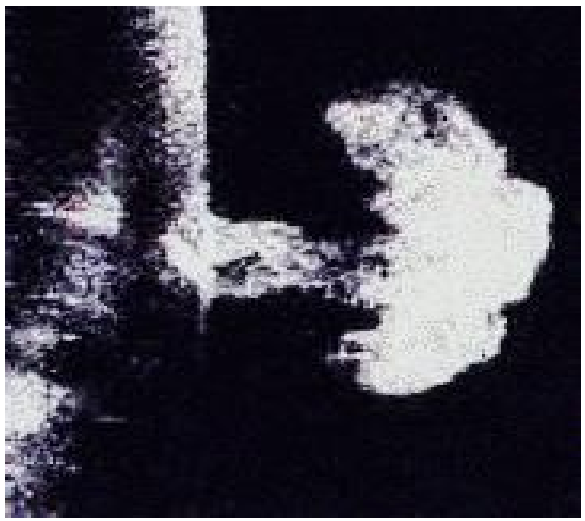
- Much military interest when first introduced
- Series of incisions cut through 90% of depth of cornea
  - Scarring flattens cornea
- No licensing or FDA approval
- Problems: weakens the eyeball, visual acuity fluctuation during day, chronic-progressive farsighted vision shift, disability glare, altitude-induced vision deterioration (read one result of this effect in the book Into Thin Air)
- Problems not apparent for 10+ years



Photorefractive Keratectomy

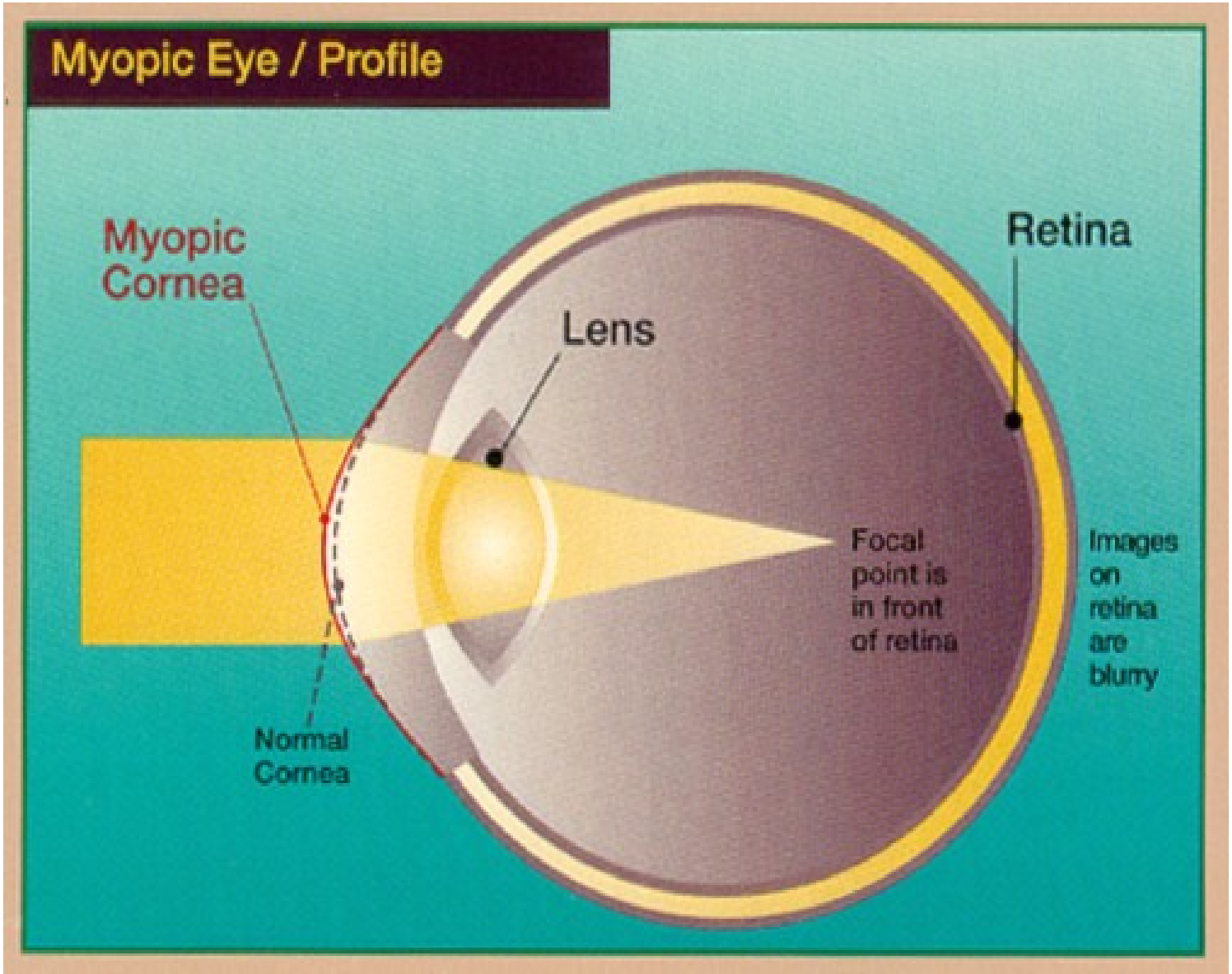
- Ultraviolet excimer laser (190 nm)
  - Vaporizes surface of cornea with little tissue heating
  - Removes <10% of depth of cornea
- FDA-approved for myopia 1996; recently approved for hyperopia; over 10 years' clinical experience and FDA trials
- Scar/haze formation from healing accounts for glare, arcs, starbursts, haze effects (esp. at night) and for some decrease in contrast sensitivity
  - Usually peaks at three to six months
  - For most, only trace scar/haze present at 1 year
- 1-8% have worsening of best corrected VA (loose 2 or more "lines" on vision chart)

Computer Controlled Excimer L



Vaporization Plume from Cornea Du

How to Alter Vision - PRK



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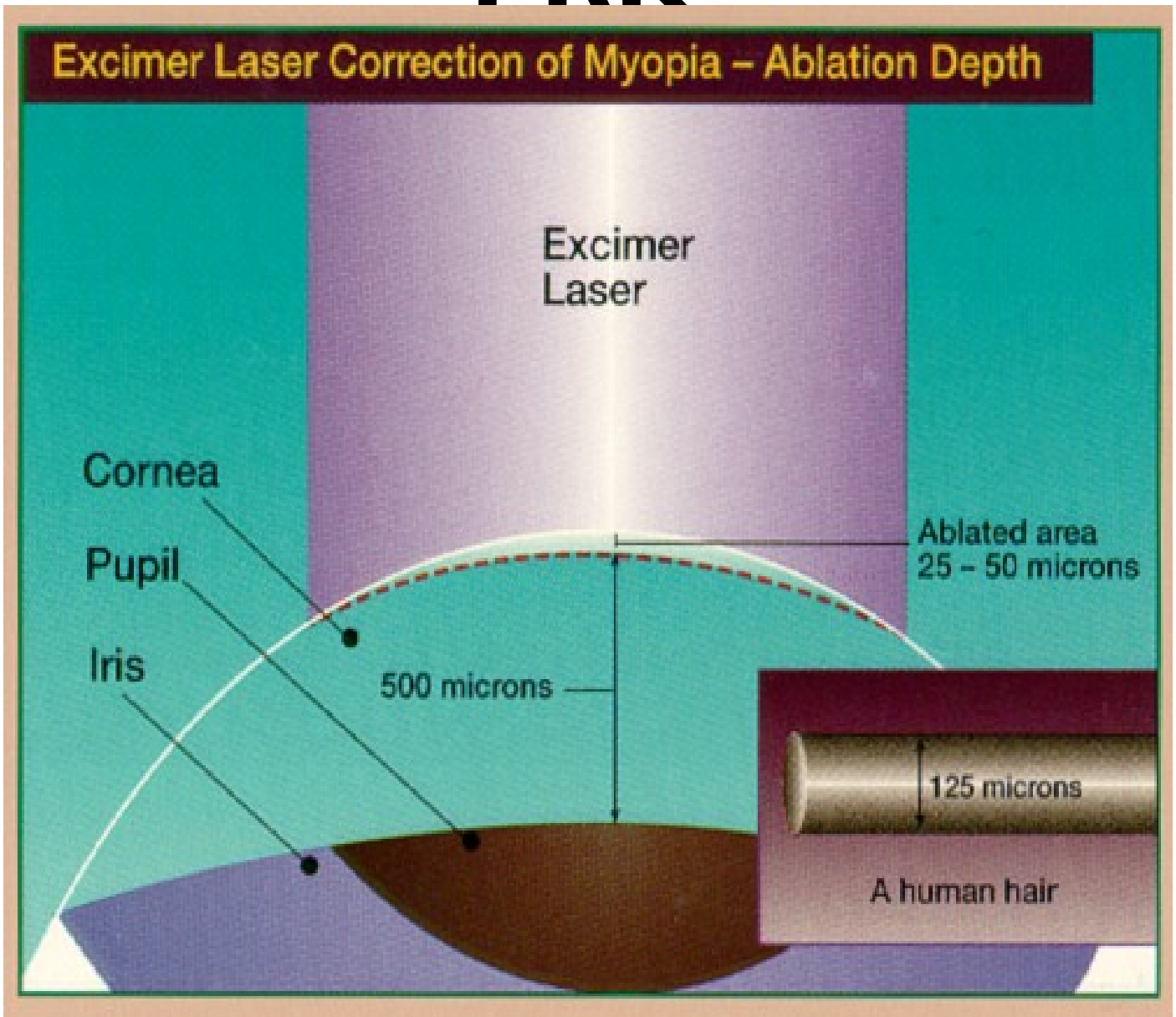

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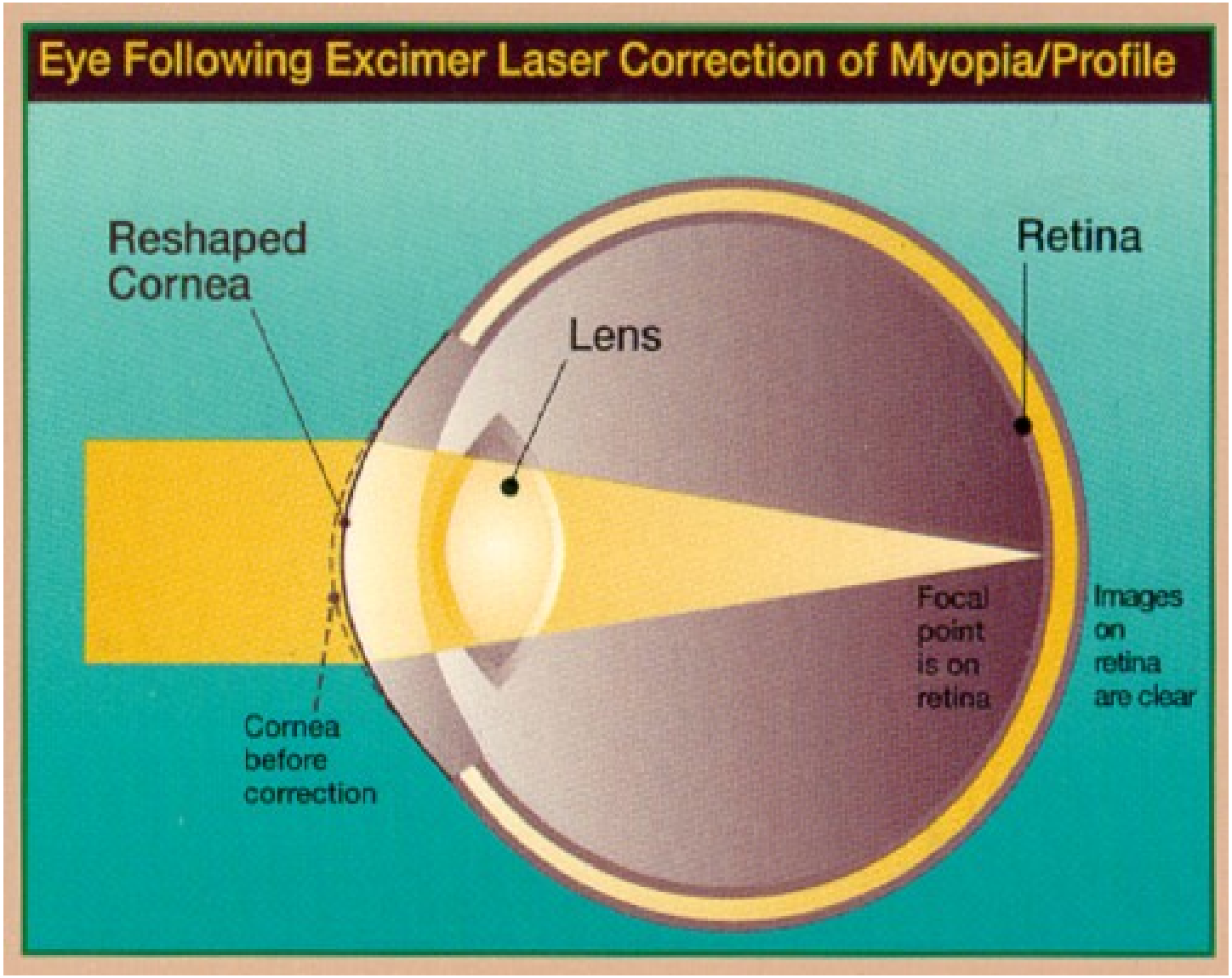

Laser In-Situ Keratomileusis

- “Flap and Zap”: thin, hinged flap of cornea sliced and laid back then PRK performed and flap laid back down
- FDA approved the Summit excimer laser for LASIK in Oct 99
- Only 3+ years clinical experience with large numbers
- Flap oriented vertically because original horizontal orientation allowed displacement with normal blinking
- Drawbacks same as for PRK with added issue of unknowns about flap stability
  - Wind blast and water blast effects likely to displace or remove the flap
  - Flap can be displaced with minor trauma
- May be impossible to wear contact lenses after LASIK

Suction Ring/Guide Plate Placed On Eye
Suction On, Keratome Makes Cornea Cut
Flap Back, Laser Aimed and Fired
Flap Dried and Relaid